NASA Lead-Free Electronics Project

Lead-Free Electronics Project II

Table of Contents

List of Tables

List of Figures

1) Background

The Joint Council on Aging Aircraft & Joint Council on Pollution Prevention Lead-Free Solder Project (JCAA/JGPP LFS) began in 2001 to: Study the effects of environmental testing on the relative reliability of lead-free and tin-lead (SnPb) solder joints and provide baseline data from the evaluation of Pb-free solders and finishes

The tests generated critical reliability data for aerospace and defense applications as documented in the Joint Test Protocol.

This testing project will build on the results from the JCAA/JGPP LFS Project focusing on the Rework of SnPb and lead-free solder alloys and will include the mixing of SnPb and lead-Free solder alloys.

2) Goals

Generate reliability data for circuit cards manufactured and reworked with SnPb and lead-free solders and subjected to rigorous environmental exposure conditions.

Provide baseline data for aerospace and defense (high-performance) applications.

a) Key questions being addressed

To what extent does Rework procedures, including SnPb and lead-free mixed solder joints, affect solder joint reliability of high-performance electronics, using SnPb as a baseline?

Table 1 Manufactured Test Vehicles

SnPb Manufactured		Lead-Free Manufactured	
Surface Finish	**Solder Alloy**	**Surface Finish**	**Solder Alloy**
Immersion Ag	Reflow = SnPb Wave = SnPb	Immersion Ag	Reflow = SAC305 Wave = Sn100C
Reflow Profile: Preheat = ~ 120 seconds @140 183°C Peak temperature = 225°C Time above reflow = 60-90 sec Ramp Rate = 2-3 °C/sec	**Wave Profile:** Solder Pot Temperature = 250°C Preheat Board T = 101°C Peak Temperature = 144°C Speed: 110 cm/min	**Reflow Profile:** Preheat = 60-120 seconds @150-190°C Peak temperature target = 243°C Reflow:~20 seconds above 230°C ~30-90 seconds above 220°C	**Wave Profile:** Solder Pot Temperature = 265°C Preheat Board T = 134°C Peak Temperature = 157°C Speed: 90 cm/min

Table 2 Rework Test Vehicles

SnPb Rework		Lead-Free Rework	
Surface Finish	**Solder Alloy**	**Surface Finish**	**Solder Alloy**
Immersion Ag ENIG	Reflow = SnPb Wave = SnPb	Immersion Ag	Reflow = SAC305 Wave = Sn100C
Reflow Profile: Preheat = ~ 120 seconds @140-183°C Peak temperature = 225°C Time above reflow = 60-90 sec Ramp Rate = 2-3 °C/sec	**Wave Profile:** Solder Pot Temperature = 250°C Preheat Board T = 101°C Peak Temperature = 144°C Speed: 110 cm/min	**Reflow Profile:** Preheat = ~ 120 seconds @140-183°C Peak temperature = 225°C Time above reflow = 60-90 sec Ramp Rate = 2-3 °C/sec	**Wave Profile:** Solder Pot Temperature = 265°C Preheat Board T = 134°C Peak Temperature = 157°C Speed: 90 cm/min

3) Test Vehicle Assemblies

1. SnPb Manufactured = *Test vehicles to be processed under standard production practices. For the JCAA/JGPP LFS Project, BAE Systems completed the work at their commercial facility located in Irving Texas.*

- **Bare Boards:**
  - 14.5"X 9"X 0.09"
  - 6 layers
  - FR4 per IPC-4101/26 with a minimum Tg of 170ºC
  - Immersion Ag surface finish
- **Components:**
  - Surface mount and through hole
- **Solder Alloys:**
  - Reflow solder alloy – SnPb
  - Wave solder alloy –SnPb

Table 3 Components – SnPb Manufactured Test Vehicles

Solder Alloy	Surface Finish	Component	Component Finish	Note
SnPb	Immersion Ag	CLCC	Sn	Convert finish to SAC305
SnPb	Immersion Ag	CLCC	SnPb	
SnPb	Immersion Ag	QFN	Matte Tin	
SnPb	Immersion Ag	TQFP - 144	Matte Tin	
SnPb	Immersion Ag	TQFP - 144	Matte Tin	Convert to SnPb, dipping lead to component body
SnPb	Immersion Ag	BGA – 225	SAC405	
SnPb	Immersion Ag	BGA – 225	SnPb	
SnPb	Immersion Ag	DIP - 20	Matte Tin	Remove 1 DIP to make room for CSP
SnPb	Immersion Ag	DIP - 20	X ~ ?	Remove 1 DIP to make room for CSP Dave Hillman looking into options
SnPb	Immersion Ag	CSP - 100	SAC105	.5 mm pitch
SnPb	Immersion Ag	CSP - 100	SnPb	.5 mm pitch
SnPb	Immersion Ag	TSOP-50	SnBi	
SnPb	Immersion Ag	TSOP-50	Matte Sn	

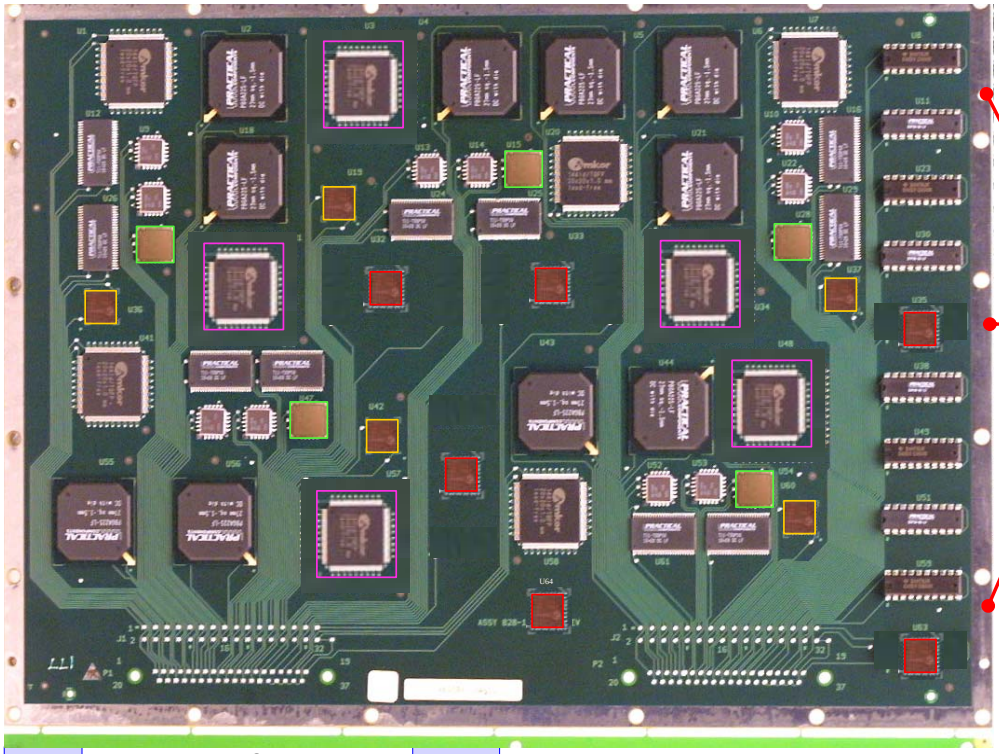

Figure 1 SnPb Manufactured Test Vehicle

Comment [O1]: Remove via and use the channel for a CSP

Comment [O2]: design includes the addition of CSP components, replacement of TQFP-208 with TQFP-144 and the replacement of PLCC with QFN component types

Table 4 Component Finish Matrix – SnPb Manufactured Test Vehicles (Thermal Cycle and Combined Environments)
Under Review

SnPb Manufactured				
RefDes	**Component**	**Component Finish**	**Reflow Solder Alloy**	**Wave Solder Alloy**
U01	TQFP-144	Matte Sn	SnPb	
U02	BGA-225	SnPb	SnPb	
U03	TQFP-144	SnPb Dip	SnPb	
U04	BGA-225	SAC405	SnPb	
U05	BGA-225	SnPb	SnPb	
U06	BGA-225	SAC405	SnPb	
U07	TQFP-144	Matte Sn	SnPb	
U08	PDIP-20	NiPdAu??		SnPb
U09	CLCC-20	SAC305	SnPb	
U10	CLCC-20	SnPb	SnPb	
U11	PDIP-20	Sn??		SnPb
U12	TSOP-50	SnBi	SnPb	
U13	CLCC-20	SAC305	SnPb	

U14	CLCC-20	SnPb	SnPb	
U15	QFN	Matte Sn	SnPb	
U16	TSOP-50	SnPb	SnPb	
U17	CLCC-20	SnPb	SnPb	
U18	BGA-225	SAC405	SnPb	
U19	CSP-100	SnPb	SnPb	
U20	TQFP-144	Matte Sn	SnPb	
U21	BGA-225	SnPb	SnPb	
U22	CLCC-20	SAC305	SnPb	
U23	PDIP-20	NiPdAu??		SnPb
U24	TSOP-50	SnPb	SnPb	
U25	TSOP-50	SnBi	SnPb	
U26	TSOP-50	SnPb	SnPb	
U27	QFN	Matte Sn	SnPb	
U28	QFN	Matte Sn	SnPb	
U29	TSOP-50	SnBi	SnPb	
U30	PDIP-20	Sn??		SnPb
U31	TQFP-144	SnPb Dip	SnPb	
U32	CSP-100	SAC105	SnPb	
U33	CSP-100	SAC105	SnPb	
U34	TQFP-144	SnPb Dip	SnPb	
U35	CSP-100	SAC105	SnPb	
U36	CSP-100	SnPb	SnPb	
U37	CSP-100	SnPb	SnPb	
U38	PDIP-20	Sn??		SnPb
U39	TSOP-50	SnBi	SnPb	
U40	TSOP-50	SnPb	SnPb	
U41	TQFP-144	Matte Sn	SnPb	
U42	CSP-100	SnPb	SnPb	
U43	BGA-225	SAC405	SnPb	
U44	BGA-225	SnPb	SnPb	
U45	CLCC-20	SnPb	SnPb	
U46	CLCC-20	SAC305	SnPb	
U47	QFN	Matte Sn	SnPb	
U48	TQFP-144	SnPb Dip	SnPb	
U49	PDIP-20	NiPdAu??		SnPb
U50	CSP-100	SAC105	SnPb	
U51	PDIP-20	Sn??		SnPb
U52	CLCC-20	SnPb	SnPb	
U53	CLCC-20	SAC305	SnPb	
U54	QFN	Matte Sn	SnPb	
U55	BGA-225	SAC405	SnPb	
U56	BGA-225	SnPb	SnPb	
U57	TQFP-144	SnPb Dip	SnPb	
U58	TQFP-144	Matte Sn	SnPb	

U59	PDIP-20	NiPdAu??		SnPb
U60	CSP-100	SnPb	SnPb	
U61	TSOP-50	SnBi	SnPb	
U62	TSOP-50	SnPb	SnPb	
U63	CSP-100	SAC105	SnPb	
U64	CSP-100	SnPb	SnPb	

2. Lead-Free Manufactured

- **Bare Boards:**
  - 14.5”X 9”X 0.09”
  - 6 layers
  - FR4 per IPC-4101/26 with a minimum Tg of 170ºC
  - Immersion Ag
- **Solder Alloys:**
  - Reflow solder alloy – SAC305
  - Wave solder alloy –SN100C

Table 5 Components – Lead-Free Manufactured Test Vehicles

Solder Alloy	Surface Finish	Component	Component Finish	Note
SAC305	Immersion Ag	CLCC	Sn	Convert finish to SAC305
SAC305	Immersion Ag	CLCC	SnPb	
SAC305	Immersion Ag	QFN	Matte Tin	
SAC305	Immersion Ag	TQFP - 144	Matte Tin	
SAC305	Immersion Ag	TQFP - 144	Matte Tin	Convert to SnPb, dipping lead to component body
SAC305	Immersion Ag	BGA – 225	SAC405	
SAC305	Immersion Ag	BGA – 225	SnPb	
SN100C	Immersion Ag	DIP - 20	Matte Tin	Remove 1 DIP to make room for CSP
SN100C	Immersion Ag	DIP - 20	X ~ ?	Remove 1 DIP to make room for CSP Dave Hillman looking into options
SAC305	Immersion Ag	CSP - 100	SAC105	.5 mm pitch
SAC305	Immersion Ag	CSP - 100	SnPb	.5 mm pitch
SAC305	Immersion Ag	TSOP-50	SnBi	
SAC305	Immersion Ag	TSOP-50	Matte Sn	

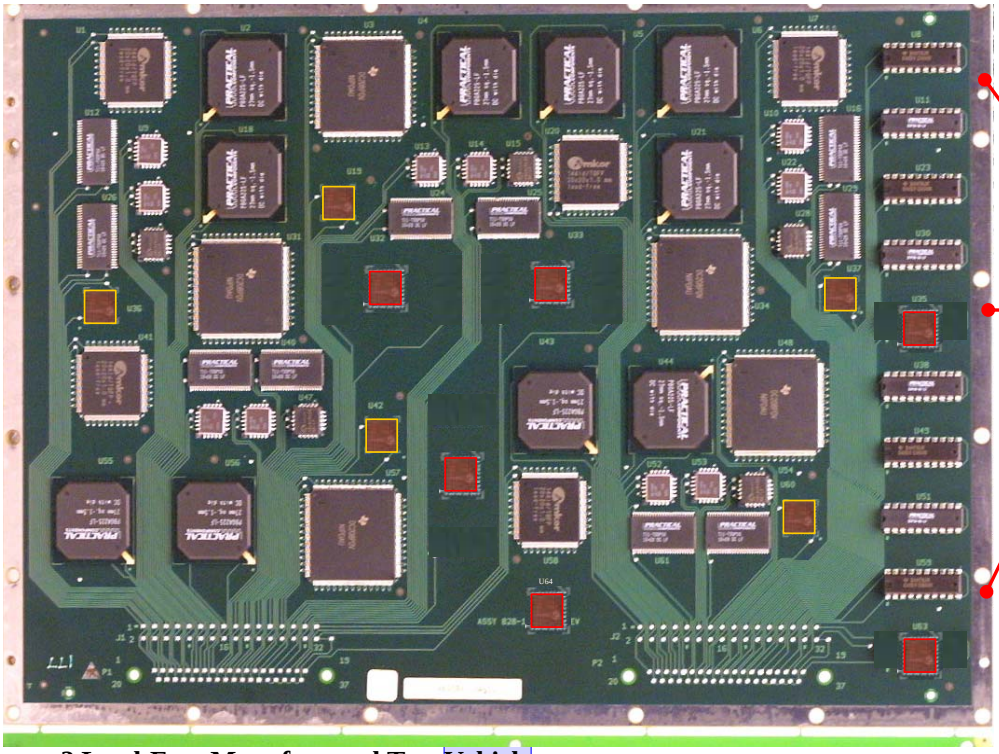

Figure 2 Lead-Free Manufactured Test Vehicle

Comment [O3]: Remove via and use the channel for a CSP

Comment [O4]: design includes the addition of CSP components, replacement of TQFP-208 with TQFP-144 and the replacement of PLCC with QFN component types

Table 6 Component Finish Matrix – Lead-Free Manufactured Test Vehicles (Thermal Cycle and Combined Environments)
Under Review

		LF Manufactured		
RefDes	**Component**	**Component Finish**	**Reflow Solder Alloy**	**Wave Solder Alloy**
U01	TQFP-144	SnPb Dip	SAC305	
U02	BGA-225	SAC405	SAC305	
U03	TQFP-144	Matte Sn	SAC305	
U04	BGA-225	SnPb	SAC305	
U05	BGA-225	SAC405	SAC305	
U06	BGA-225	SnPb	SAC305	
U07	TQFP-144	SnPb Dip	SAC305	
U08	PDIP-20	NiPdAu??		SN100C
U09	CLCC-20	SnPb	SAC305	
U10	CLCC-20	SAC305	SAC305	
U11	PDIP-20	Sn??		SN100C
U12	TSOP-50	SnPb	SAC305	
U13	CLCC-20	SnPb	SAC305	
U14	CLCC-20	SAC305	SAC305	

U15	QFN	Matte Sn	SAC305	
U16	TSOP-50	SnBi	SAC305	
U17	CLCC-20	SAC305	SAC305	
U18	BGA-225	SnPb	SAC305	
U19	CSP-100	SAC105	SAC305	
U20	TQFP-144	SnPb Dip	SAC305	
U21	BGA-225	SAC405	SAC305	
U22	CLCC-20	SnPb	SAC305	
U23	PDIP-20	NiPdAu??		SN100C
U24	TSOP-50	SnBi	SAC305	
U25	TSOP-50	SnPb	SAC305	
U26	TSOP-50	SnBi	SAC305	
U27	QFN	Matte Sn	SAC305	
U28	QFN	Matte Sn	SAC305	
U29	TSOP-50	SnPb	SAC305	
U30	PDIP-20	Sn??		SN100C
U31	TQFP-144	Matte Sn	SAC305	
U32	CSP-100	SnPb	SAC305	
U33	CSP-100	SnPb	SAC305	
U34	TQFP-144	Matte Sn	SAC305	
U35	CSP-100	SnPb	SAC305	
U36	CSP-100	SAC105	SAC305	
U37	CSP-100	SAC105	SAC305	
U38	PDIP-20	Sn??		SN100C
U39	TSOP-50	SnPb	SAC305	
U40	TSOP-50	SnBi	SAC305	
U41	TQFP-144	SnPb Dip	SAC305	
U42	CSP-100	SAC105	SAC305	
U43	BGA-225	SnPb	SAC305	
U44	BGA-225	SAC405	SAC305	
U45	CLCC-20	SAC305	SAC305	
U46	CLCC-20	SnPb	SAC305	
U47	QFN	Matte Sn	SAC305	
U48	TQFP-144	Matte Sn	SAC305	
U49	PDIP-20	NiPdAu??		SN100C
U50	CSP-100	SnPb	SAC305	
U51	PDIP-20	Sn??		SN100C
U52	CLCC-20	SAC305	SAC305	
U53	CLCC-20	SnPb	SAC305	
U54	QFN	Matte Sn	SAC305	
U55	BGA-225	SnPb	SAC305	
U56	BGA-225	SAC405	SAC305	
U57	TQFP-144	Matte Sn	SAC305	
U58	TQFP-144	SnPb Dip	SAC305	
U59	PDIP-20	NiPdAu??		SN100C

U60	CSP-100	SAC105	SAC305	
U61	TSOP-50	SnPb	SAC305	
U62	TSOP-50	SnBi	SAC305	
U63	CSP-100	SnPb	SAC305	
U64	CSP-100	SAC105	SAC305	

3. SnPb Rework = *Fully characterize one SnPb Rework board to see if there are any residual heating effects caused by the rework procedures*

- **Bare Boards:**
  - 14.5"X 9"X 0.09"
  - 6 layers
  - FR4 per IPC-4101/26 with a minimum Tg of 170ºC
  - Immersion Ag and ENIG; 5 boards will have an ENIG surface finish
- **Solder Alloys:**
  - Reflow solder alloy – SnPb
  - Wave solder alloy –SnPb

Table 7 Components – SnPb Rework Test Vehicles

Solder Alloy	Surface Finish	Component	Component Finish	Note
SnPb	Immersion Ag & ENIG	CLCC	Sn	Convert finish to SAC305
SnPb	Immersion Ag & ENIG	CLCC	SnPb	
SnPb	Immersion Ag & ENIG	QFN	Matte Tin	
SnPb	Immersion Ag & ENIG	TQFP - 144	Matte Tin	
SnPb	Immersion Ag & ENIG	TQFP - 144	Matte Tin	Convert to SnPb, dipping lead to component body
SnPb	Immersion Ag & ENIG	BGA – 225	SAC405	
SnPb	Immersion Ag & ENIG	BGA – 225	SnPb	
SnPb	Immersion Ag & ENIG	DIP - 20	Matte Tin	Remove 1 DIP to make room for CSP
SnPb	Immersion Ag & ENIG	DIP - 20	X ~ ?	Remove 1 DIP to make room for CSP Dave Hillman looking into options
SnPb	Immersion Ag & ENIG	CSP - 100	SAC105	.5 mm pitch
SnPb	Immersion Ag & ENIG	CSP - 100	SnPb	.5 mm pitch
SnPb	Immersion Ag	TSOP-50	SnBi	
SnPb	Immersion Ag	TSOP-50	Matte Sn	

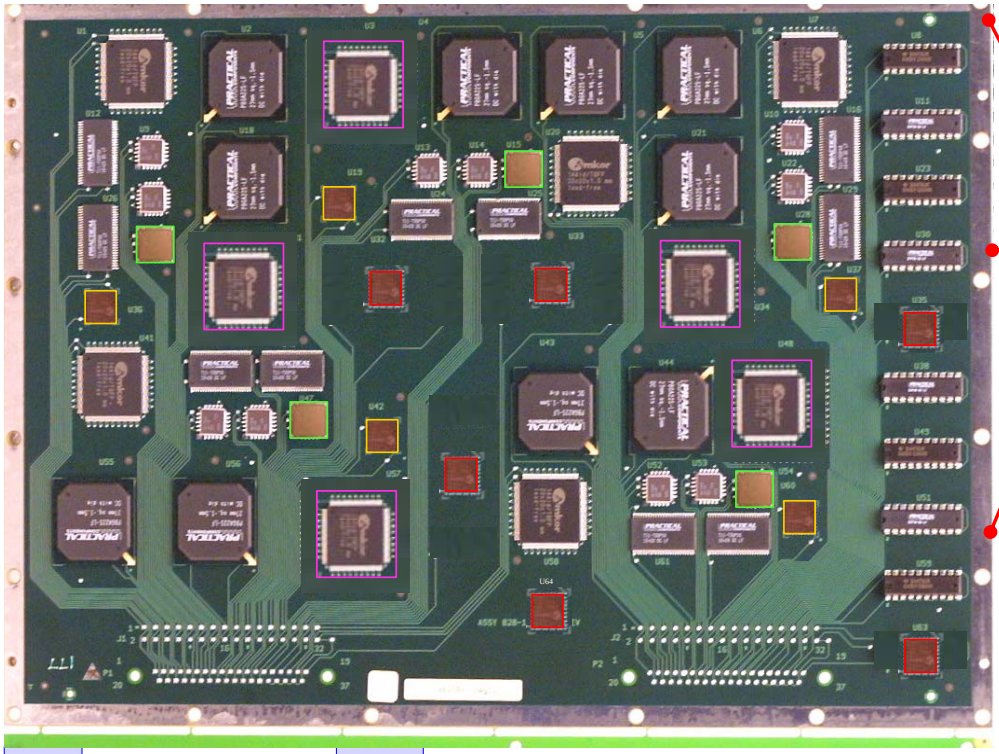

Figure 3 SnPb Rework Test Vehicle

Comment [O5]: Remove via and use the channel for a CSP

Comment [O6]: design includes the addition of CSP components, replacement of TQFP-208 with TQFP-144 and the replacement of PLCC with QFN component types

- **SnPb Rework Procedure**
  - Remove component, wick away excess solder from pad then place a new component on the board using the correct solder alloy. The rework process will be further defined as this proposal is being developed.
  - More shielding and heat control with regards to surrounding components will be used during rework procedures.
  - For the BGA components use tacky flux for all rework procedures except for the ENIG test vehicles in which solder past should be used.
  - Need to determine how many components can be reworked for each component type for the SnPb and lead-free Rework test vehicles.

14 components to be Reworked per test vehicle

- 6 - BGA 225:
  - 3 - SnPb/SnPb = U02, U21, U56
  - 3 – SAC/SnPb = U06, U18, U43
- 2 -PDIP-20 = U11, U51
- 6 -TSOP-50:
  - 3 - SnPb/SnPb = U16, U26, U62
  - 3 – SnBi/SnPb = U12, U25, U61

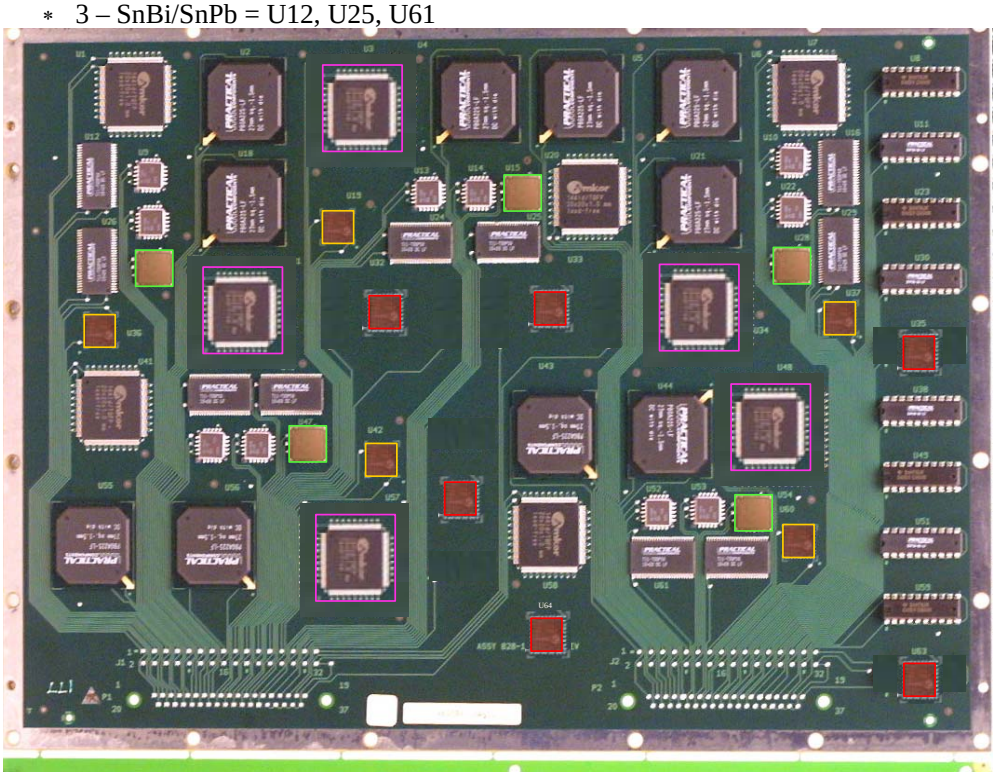

Figure 4 SnPb Rework Test Vehicle, Components to be Reworked

Table 8 Component Finish Matrix – SnPb Rework Test Vehicles (Thermal Cycle and Combined Environments)
Under Review

			SnPb Rework			
RefDes	**Component**	**Original Component Finish**	**Reflow Solder Alloy**	**Wave Solder Alloy**	**New Component Finish**	**Rework Solder**
U01	TQFP-144	Matte Sn	SnPb			
U02	BGA-225	SnPb	SnPb		SnPb	SnPb
U03	TQFP-144	SnPb Dip	SnPb			
U04	BGA-225	SAC405	SnPb			
U05	BGA-225	SnPb	SnPb			

U06	BGA-225	SAC405	SnPb		SAC405	SnPb
U07	TQFP-144	Matte Sn	SnPb			
U08	PDIP-20	NiPdAu??		SnPb		
U09	CLCC-20	SAC305	SnPb			
U10	CLCC-20	SnPb	SnPb			
U11	PDIP-20	Sn??		SnPb	Sn??	SnPb
U12	TSOP-50	SnBi	SnPb		SnBi	SnPb
U13	CLCC-20	SAC305	SnPb			
U14	CLCC-20	SnPb	SnPb			
U15	QFN	Matte Sn	SnPb			
U16	TSOP-50	SnPb	SnPb		SnPb	SnPb
U17	CLCC-20	SnPb	SnPb			
U18	BGA-225	SAC405	SnPb		SAC405	SnPb
U19	CSP-100	SnPb	SnPb			
U20	TQFP-144	Matte Sn	SnPb			
U21	BGA-225	SnPb	SnPb		SnPb	SnPb
U22	CLCC-20	SAC305	SnPb			
U23	PDIP-20	NiPdAu??		SnPb		
U24	TSOP-50	SnPb	SnPb			
U25	TSOP-50	SnBi	SnPb		SnBi	SnPb
U26	TSOP-50	SnPb	SnPb		SnPb	SnPb
U27	QFN	Matte Sn	SnPb			
U28	QFN	Matte Sn	SnPb			
U29	TSOP-50	SnBi	SnPb			
U30	PDIP-20	Sn??		SnPb		
U31	TQFP-144	SnPb Dip	SnPb			
U32	CSP-100	SAC105	SnPb			
U33	CSP-100	SAC105	SnPb			
U34	TQFP-144	SnPb Dip	SnPb			
U35	CSP-100	SAC105	SnPb			
U36	CSP-100	SnPb	SnPb			
U37	CSP-100	SnPb	SnPb			
U38	PDIP-20	Sn??		SnPb		
U39	TSOP-50	SnBi	SnPb			
U40	TSOP-50	SnPb	SnPb			
U41	TQFP-144	Matte Sn	SnPb			
U42	CSP-100	SnPb	SnPb			
U43	BGA-225	SAC405	SnPb		SAC405	SnPb
U44	BGA-225	SnPb	SnPb			
U45	CLCC-20	SnPb	SnPb			
U46	CLCC-20	SAC305	SnPb			
U47	QFN	Matte Sn	SnPb			
U48	TQFP-144	SnPb Dip	SnPb			
U49	PDIP-20	NiPdAu??		SnPb		
U50	CSP-100	SAC105	SnPb			

U51	PDIP-20	Sn??		SnPb	Sn??	SnPb
U52	CLCC-20	SnPb	SnPb			
U53	CLCC-20	SAC305	SnPb			
U54	QFN	Matte Sn	SnPb			
U55	BGA-225	SAC405	SnPb			
U56	BGA-225	SnPb	SnPb		SnPb	SnPb
U57	TQFP-144	SnPb Dip	SnPb			
U58	TQFP-144	Matte Sn	SnPb			
U59	PDIP-20	NiPdAu??		SnPb		
U60	CSP-100	SnPb	SnPb			
U61	TSOP-50	SnBi	SnPb		SnBi	SnPb
U62	TSOP-50	SnPb	SnPb		SnPb	SnPb
U63	CSP-100	SAC105	SnPb			
U64	CSP-100	SnPb	SnPb			

4. Lead-Free Rework = *Fully characterize one SnPb Rework board to see if there are any residual heating effects caused by the rework procedures*

- **Bare Boards:**
  - 14.5"X 9"X 0.09"
  - 6 layers
  - FR4 per IPC-4101/26 with a minimum Tg of 170ºC
  - Immersion Ag
- **Solder Alloys:**
  - Reflow solder alloy – SAC305
  - Wave solder alloy –SN100C

Table 9 Components – Lead-Free Rework Test Vehicles

Solder Alloy	Surface Finish	Component	Component Finish	Note
SAC305	Immersion Ag	CLCC	Sn	Convert finish to SAC305
SAC305	Immersion Ag	CLCC	SnPb	
SAC305	Immersion Ag	QFN	Matte Tin	
SAC305	Immersion Ag	TQFP - 144	Matte Tin	
SAC305	Immersion Ag	TQFP - 144	Matte Tin	Convert to SnPb, dipping lead to component body
SAC305	Immersion Ag	BGA – 225	SAC405	
SAC305	Immersion Ag	BGA – 225	SnPb	
SN100C	Immersion Ag	DIP - 20	Matte Tin	Remove 1 DIP to make room for CSP
SN100C	Immersion Ag	DIP - 20	X ~ ?	Remove 1 DIP to make room for CSP Dave Hillman looking into options
SAC305	Immersion Ag	CSP - 100	SAC105	.5 mm pitch
SAC305	Immersion Ag	CSP - 100	SnPb	.5 mm pitch
SAC305	Immersion Ag	TSOP-50	SnBi	
SAC305	Immersion Ag	TSOP-50	Matte Sn	

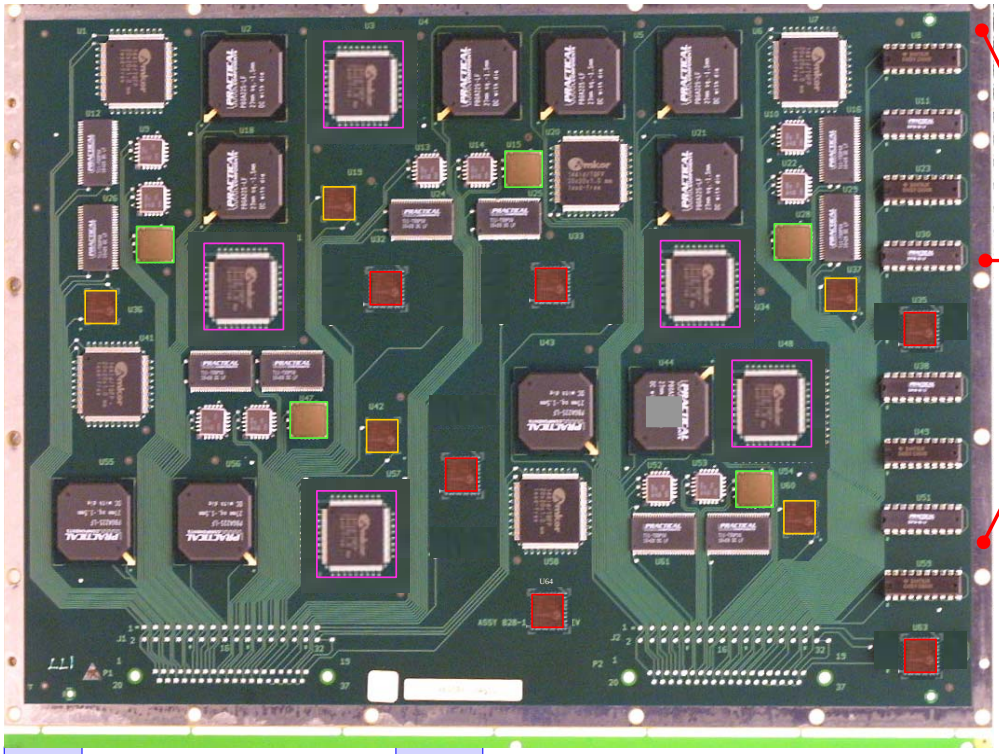

Figure 5 Lead-Free Rework Test Vehicle

Comment [O7]: Remove via and use the channel for a CSP

Comment [O8]: design includes the addition of CSP components, replacement of TQFP-208 with TQFP-144 and the replacement of PLCC with QFN component types

- **Lead-Free Rework Procedure**
  - Remove component, wick away excess solder from pad then place a new component on the board using lead-free solder alloy. The rework process will be further defined as this proposal is being developed.
  - More shielding and heat control with regards to surrounding components will be used during rework procedures.
  - For the BGA components use tacky flux
  - Need to determine how many components can be reworked for each component type for the SnPb and lead-free Rework test vehicles.
  - For the Sn100C solder alloy used for the DIP components, a mini-wave solder pot should be used.

14 components to be Reworked per test vehicle

- 6 - BGA 225:
  - 3 - SAC/SAC = U02, U21, U56
  - 3 – SnPb/SAC = U06, U18, U43
- 2 -PDIP-20 = U11, U51
- 6 -TSOP-50:
  - 3 - SnBi/SAC = U16, U26, U62
  - 3 – SnPb/SAC = U12, U25, U61

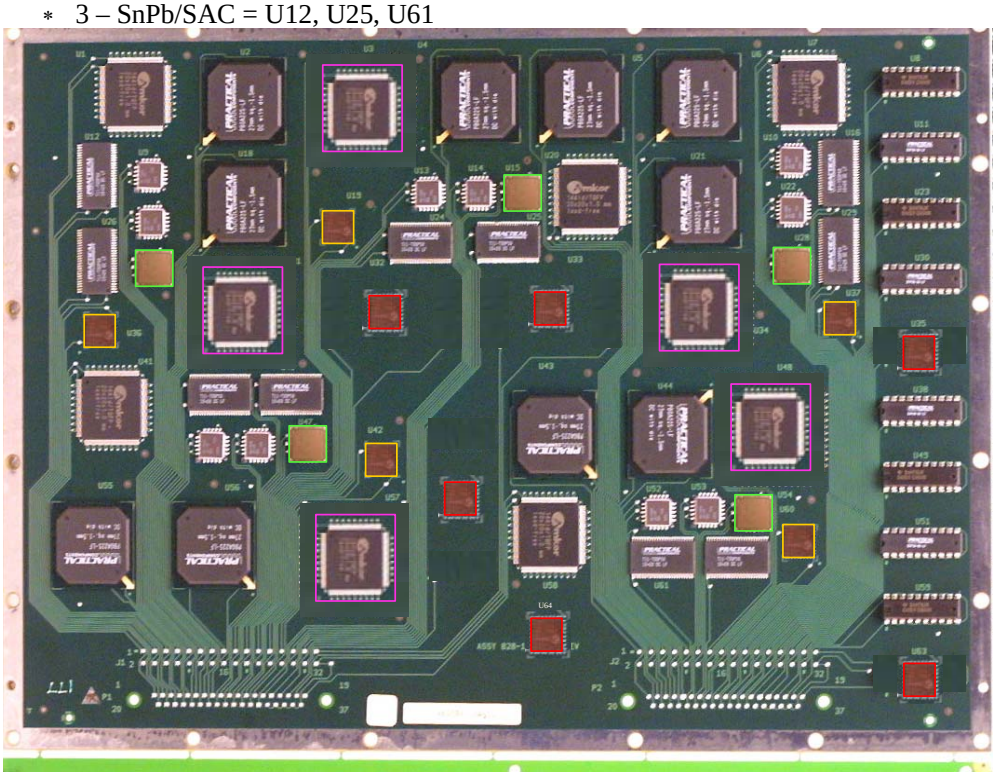

Figure 6 Lead-Free Rework Test Vehicle, Components to be Reworked

Table 10 Component Finish Matrix – Lead-Free Rework Test Vehicles (Thermal Cycle and Combined Environments)
Under Review

			LF Rework			
RefDes	**Component**	**Component Finish**	**Reflow Solder Alloy**	**Wave Solder Alloy**	**New Component Finish**	**Rework Solder**
U01	TQFP-144	SnPb Dip	SAC305			
U02	BGA-225	SAC405	SAC305		SAC405	SAC305
U03	TQFP-144	Matte Sn	SAC305			
U04	BGA-225	SnPb	SAC305			
U05	BGA-225	SAC405	SAC305			
U06	BGA-225	SnPb	SAC305		SnPb	SAC305

U07	TQFP-144	SnPb Dip	SAC305			
U08	PDIP-20	NiPdAu??		SN100C		
U09	CLCC-20	SnPb	SAC305			
U10	CLCC-20	SAC305	SAC305			
U11	PDIP-20	Sn??		SN100C	Sn??	SN100C
U12	TSOP-50	SnPb	SAC305		SnPb	SAC305
U13	CLCC-20	SnPb	SAC305			
U14	CLCC-20	SAC305	SAC305			
U15	QFN	Matte Sn	SAC305			
U16	TSOP-50	SnBi	SAC305		SnBi	SAC305
U17	CLCC-20	SAC305	SAC305			
U18	BGA-225	SnPb	SAC305		SnPb	SAC305
U19	CSP-100	SAC105	SAC305			
U20	TQFP-144	SnPb Dip	SAC305			
U21	BGA-225	SAC405	SAC305		SAC405	SAC305
U22	CLCC-20	SnPb	SAC305			
U23	PDIP-20	NiPdAu??		SN100C		
U24	TSOP-50	SnBi	SAC305			
U25	TSOP-50	SnPb	SAC305		SnPb	SAC305
U26	TSOP-50	SnBi	SAC305		SnBi	SAC305
U27	QFN	Matte Sn	SAC305			
U28	QFN	Matte Sn	SAC305			
U29	TSOP-50	SnPb	SAC305			
U30	PDIP-20	Sn??		SN100C		
U31	TQFP-144	Matte Sn	SAC305			
U32	CSP-100	SnPb	SAC305			
U33	CSP-100	SnPb	SAC305			
U34	TQFP-144	Matte Sn	SAC305			
U35	CSP-100	SnPb	SAC305			
U36	CSP-100	SAC105	SAC305			
U37	CSP-100	SAC105	SAC305			
U38	PDIP-20	Sn??		SN100C		
U39	TSOP-50	SnPb	SAC305			
U40	TSOP-50	SnBi	SAC305			
U41	TQFP-144	SnPb Dip	SAC305			
U42	CSP-100	SAC105	SAC305			
U43	BGA-225	SnPb	SAC305		SnPb	SAC305
U44	BGA-225	SAC405	SAC305			
U45	CLCC-20	SAC305	SAC305			
U46	CLCC-20	SnPb	SAC305			
U47	QFN	Matte Sn	SAC305			
U48	TQFP-144	Matte Sn	SAC305			
U49	PDIP-20	NiPdAu??		SN100C		
U50	CSP-100	SnPb	SAC305			
U51	PDIP-20	Sn??		SN100C	Sn??	SN100C

U52	CLCC-20	SAC305	SAC305			
U53	CLCC-20	SnPb	SAC305			
U54	QFN	Matte Sn	SAC305			
U55	BGA-225	SnPb	SAC305			
U56	BGA-225	SAC405	SAC305		SAC405	SAC305
U57	TQFP-144	Matte Sn	SAC305			
U58	TQFP-144	SnPb Dip	SAC305			
U59	PDIP-20	NiPdAu??		SN100C		
U60	CSP-100	SAC105	SAC305			
U61	TSOP-50	SnPb	SAC305		SnPb	SAC305
U62	TSOP-50	SnBi	SAC305		SnBi	SAC305
U63	CSP-100	SnPb	SAC305			
U64	CSP-100	SAC105	SAC305			

4) Test Vehicles

Table 11 Test Vehicle Numbers; Manufactured

Assembly Details		
Manufactured	**SnPb**	**Lead-Free**
Board Qty,.	**30**	**30**
Surface Finish	Immersion Ag	Immersion Ag
Solder Paste	SnPb	SAC305
Wave Solder	SnPb	SN100C
Solder Wire - SM[b]	SnPb	SnAgCu
Solder Wire - PTH[c]	N/A	N/A
b: surface mount components		
c: plated through hole components		

Table 12 Test Vehicles Numbers; Rework

Assembly Details			
Rework	**SnPb**	**SnPb**	**Lead-Free**
Board Qty,.	**30**	**8**	**30**
Surface Finish	Immersion Ag	ENIG	Immersion Ag
Solder Paste	SnPb	SAC305	SAC305
Wave Solder	SnPb	SN100C	SN100C
Solder Wire - SM[b]	SnPb	SnAgCu	SnAgCu
Solder Wire - PTH[c]	SnPb	SN100C	SN100C
b: surface mount components			
c: plated through hole components			

5) Testing Activities

Table 13 Test Vehicle Tracking

Project Activity	Performer	No. of Test Vehicles		Reference	Notes
		Mfg.	Rework		
Testing Prep					
PWA Assy & Rework	**BAE Systems Lockheed Martin Apsco**	**60**	**68**	--	
Extra Boards	**N/A**	4	5	--	2 of each type of board from SnPb and Lead-1 SnPb Rework with ENIG surface finish
Component Characterization	**Rockwell Collins**	2	3	--	1 of each type of board from SnPb and Lead-1 SnPb Rework with ENIG surface finish
Testing					
Thermal Cycling: -55°C to +125°C 30 min. high temp dwell	**Rockwell Collins**	10	11	IPC-SM-785	5 of each type of board from SnPb and Lead-1 SnPb Rework with ENIG surface finish
Thermal Cycling: -20°C to +80°C 15 min. high temp dwell	**Boeing**	10	11	IPC-SM-785	5 of each type of board from SnPb and Lead-1 SnPb Rework with ENIG surface finish
Combined Environments Testing	**Raytheon**	10	11	MIL-STD-810F	5 of each type of board from SnPb and Lead-1 SnPb Rework with ENIG surface finish
Vibration	**Boeing**	10	11	MIL-STD-810F	5 of each type of board from SnPb and Lead-1 SnPb Rework with ENIG surface finish
Mechanical Shock	**?**	10	11	MIL-STD-810F	5 of each type of board from SnPb and Lead-1 SnPb Rework with ENIG surface finish
Drop Testing	**Celestica**	4	5	**?**	2 of each type of board from SnPb and Lead-1 SnPb Rework with ENIG surface finish
Failure Analysis	**COM DEV Boeing Celestica**	**#?**	**#?**	--	These are SnPb and Lead-Free test vehicles t have completed testing and do not count agai the total number of test vehicles needed

6) References

IPC/EIA J-STD-001 Revision C	IPC-SM-785	IPC-TM-650
ANSI/J-STD-003	IPC-9201	IPC-9701
IPC-2221	MIL-STD-810F	IPC-A-610
IPC-2222	IPC-4101/26	IPC-6012